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PREDICTION OF NOISE FROM TRAINS

B. HEMSWORTH

RESEARCH AND DEVELOPMENT DIVISION, BRITISH RAIL

Introduction

The ability to predict noise immission levels from a variety of sources is becoming increasingly important. This is accepted as being applicable to railway noise especially when one considers recent plans for the development of our railway system, e.g. Channel Tunnel Rail Link, East Coast Main Line diversion near Selby, and the increasing practice of using land near existing railways for residential development.

The parallel situation for predicting road traffic noise is well documented and certainly the procedures of "Calculation of Road Traffic Noise" HMSO 1975 are widely accepted.

This is not the case for railway noise and this paper attempts to describe, and where possible quantify, the effect of various important parameters on the noise levels caused by the passage of trains.

In common with other prediction models it is based on empirical data, with base noise level data derived from measurements of British Railways rolling stock. Propagation information and corrections for certain design conditions encompass the results obtained throughout the world.

Sources of Train Noise

For conventional wheel on rail trains running up to today's maximum operational speeds it is only necessary to consider two sources, i.e. motive power noise and wheel/rail noise. (Recent investigations have been carried out to assess aerodynamic noise, but the results suggest that it is not a major contributing factor for trains currently in operation).

The relative importance of these sources depends on many factors but wheel/rail noise can never be ignored for moving trains and so it seems reasonable to consider that source first.

Peak Wheel/Rail Noise

(i) Source Effects

It is necessary to identify

(a) Type(s) of rolling stock for which prediction is required.

(b) Speed or range of speeds for each type identified in (a)

(c) Type of track, i.e. continuously welded rail or jointed rails.

Wheel/rail noise is speed dependent and generally taken to be proportional to the logarithm of train speed. The constant of proportionality varies between 20 and 40 depending on the type of rolling stock. If there are no data available for this constant assume a value of 30 for initial calculations.

For a particular speed (on the same type of track) peak levels can vary by 10 dBA or so for different types of rolling stock. Trains on jointed track give levels about 5 dBA higher than for the same trains on continuously welded rail, but again this will vary slightly for different types of rolling stock.

From above it is possible to determine a base level for peak noise at 25 m from the track and some examples are given below, for trains on good quality continuously welded rail.

Mk II Intercity coaches (tread braked)	at 160 km/h	=	93 dBA
Mk III Intercity coaches (disc braked)	at 160 km/h	=	85 dBA
MGR (disc braked coal freight)	at 70 km/h	=	79 dBA

At this distance from the track the peak noise level is independent of train length, unless one is considering the noise from a single vehicle.

(ii) Propagation Effects

Wheel/rail noise can be modelled adequately as a line of incoherent dipoles. This imposes a particular geometric decay which is dependent upon train length.

In practice, of course, other attenuation factors must be included and the effect of ground absorption is probably the most important if only for the fact that it is present all the time.

One way to predict unobstructed attenuation is to superimpose ground absorption (obtainable from a variety of references) onto the geometric decay, but more often the two effects are combined through measurements taken on flat open sites. Since trains tend to run in fixed and consistent formations this allows a single decay curve to be given for a particular type of train.

Where predictions are required for the same rolling stock but different train lengths, corrections based on the geometric decay curve can be applied.

Other factors may also have to be included and these are summarised below

(a) track on embankment - this does not increase source noise, but reduction in ground absorption gives higher immission levels than at grade case (in limit assume geometric decay only).

(b) track in cutting - behaves as a barrier but insufficient statistically validated data available at present (suggest 5 dBA approximate reduction from at grade case where line of sight of wheels obscured by edge of cutting).

(c) purpose designed barriers or earth berms - data obtainable from various references, but barriers close to track can present railway operational and maintenance difficulties.

(d) shielding by buildings - reference 1 gives summary of likely attenuation.

There are other features which would need to be considered in a comprehensive prediction method but the ones above cover the majority of cases.

Peak Motive Power Noise

(i) Source Effects

The main difference between this and wheel/rail noise is that it is independent of train speed but dependent on type of motive power unit and its power demand.

As a rule of thumb it can be taken that motive power noise can be ignored where overhead electric traction is involved, and for diesel hauled passenger trains with tread braked coaches (the majority) where train speed is in excess of about 100 km/h. In all other cases a motive power noise must be accounted for.

Reference 2 gives a summary of levels from different diesel locomotives for full power conditions. These locomotives vary in power from 1150 BHP to 3500 BHP but the peak noise is not proportional to BHP but controlled by other design differences.

As a first approximation it is probable that a level of 90 dBA at 25 m from the track for the locomotive on full power is a reasonable assumption for all main line diesel locomotives, although if the type can be identified data from reference 2 should be used.

(ii) Propagation Effects

Locomotive noise is usually modelled as radiation from a point source, giving a geometric decay of 6 dBA/distance doubling.

The source is usually high on the locomotive body and contains a large amount of low frequency energy. Thus the effect of the factors discussed for wheel/rail noise propagation are likely to be marginal. In the absence of measured data at different distances from the track 6dBA/distance doubling can be taken as being applicable.

Calculation of L_{eq}

The results of a recent social survey on railway noise annoyance in the UK (reference 3) suggests that L_{eq}, measured over 24 hours, is the best index to use for environmental assessments of noise from railways.

In calculating L_{eq} it is necessary to decide whether motive power noise is important and it is interesting to note that for low speed full power conditions an increase in train speed will give a reduction in L_{eq}. At a speed where wheel/rail noise (duration and level) becomes dominant L_{eq} will then increase as the train speed increases. A methodology for determining L_{eq} (or more precisely L_{AX}) from peak noise levels is given in reference 4 and a comparison between this and direct measurement shows good agreement.

PREDICTION OF NOISE FROM TRAINS

One of the most often asked questions concerning railway noise prediction relates to the maximum distance from the track for which data should be provided. Perhaps this is best answered by giving L_{eq} values for a typical mixed line containing high speed diesel hauled passenger trains and various freight (total number of trains ≈ 120/day).

Distance from track m	25	50	100	200
24 hr L_{eq} dBA	67	64	59	54

The above table applies to an open site where only ground absorption is considered as excess attenuation over geometric decay.

General Comments

This paper gives some insight into the main factors which should be considered for railway noise prediction. As more measured data become available then the scope of the prediction method broadens. This is a long process, however, and it will be some time yet before a method capable of covering every situation will be available.

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References

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